09/319460

PCT/GB97/03344

The Patent Office

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP9 1RH

REC'D 20 MAR 1998
WIPO PCT

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 4 MAR 1998

PRIORITY DOCUMENT

BEST AVAILABLE COPY

CERTIFIED COPY OF PRIORITY DOCUMENT

_atents Form 1/77

Patents Act 1977
(Rule 16)

-6 DEC 1996
LONDON

The Patent Office

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

10DEC96 E239485-1 D02829
P01/7700 25.00

The Patent Office
~~Cardiff Road~~
Newport
Gwent NP9 1RH

1.	Your reference	J.24468 GB
2.	Patent application number *(The Patent Office will fill in this part)*	**9625475.0** -6 DEC 1996
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	INTERNATIONAL MOBILE SATELLITE ORGANIZATION 99 City Road London EC1Y 1AX
	Patents ADP number *(if you know it)*	06636701001
	If the applicant is a corporate body, give the country/state of its incorporation	An International Organization established under the Inmarsat Convention
4.	Title of the invention	COMMUNICATION METHOD AND APPARATUS
5.	Name of your agent *(if you have one)*	R G C JENKINS & CO
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	26 Caxton Street London SW1H ORJ
	Patents ADP number *(if you know it)*	950001

		Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number			

		Number of earlier application	Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application		

8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	28
Claim*(s)*	10
Abstract	1
Drawing*(s)*	6

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature RGC Jenkins & Co. Date 6/12/96

R G C Jenkins & Co 6th December 96

12. Name and daytime telephone number of person to contact in the United Kingdom DAVID C MUSKER 0171 931 7141

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

COMMUNICATION METHOD AND APPARATUS

The present invention relates to communication method and apparatus and particularly, but not exclusively, to a communication system for providing variable bandwidth communication to a mobile terminal.

In some satellite and terrestrial mobile communication systems, terminals are available which provide both voice and data communication. For example, some GSM mobile telephones are connectable to data terminals, such as portable computers. During a data call using such mobile terminals, TDMA slots are assigned to the data call in a similar way as to a voice call, so that a constant bandwidth connection is established both in the forward and return direction.

Mobile satellite systems, such as the Inmarsat-B™, Inmarsat-C™ and Inmarsat-M™ satellite communication systems, allow fixed-bandwidth data communications.

Such systems are suitable for the exchange of some types of data, but are primarily designed for voice communications, which require a constant symmetrical data rate. Such systems are not optimised for both data and voice communication.

There is an increasing demand for data communications which require intermittent bursts of data to be sent or received at a high data rate, while

requiring only low data rate communication at other times. For example, it is desirable when using a Web browser for requested pages to be downloaded as quickly as possible to the user terminal, but little or no bandwidth is required in the forward direction while the user reads the downloaded page. Such usage is also very asymmetrical, since the user only needs to send requests for new pages or small amounts of data in the return direction. The use of such applications over the GSM system is unsatisfactory, since for some of the time during the data call the allocated bandwidth is not used, but while large amounts of data are being downloaded, the allocated bandwidth is insufficient.

Furthermore, it would be desirable to allow multiple calls to be handled concurrently by the same mobile terminal. For example, during a telephone call, a mobile user may wish to refer to data from an online database, or receive an incoming facsimile.

A variable data rate satellite communication system is described in US 4,256,925. In this system, a satellite is used for communication between a plurality of ground stations. Each ground station requests a proportion of the total channel capacity in accordance with the traffic load of voice and data call to that ground station. A reference station in

the network allocates the channel capacity among the stations.

An ATM (asynchronous transfer mode) satellite communication system is described in US 5,363,374. Each earth station requests sporadic connection to the communication system and a central management station determines whether to accept or refuse the connection according to the available bandwidth.

However, such systems do not address the forward and return bandwidth requirements between an earth station and a mobile terminal, and do not describe how individual calls may be set up or multiple calls handled concurrently. Nor do they address how voice calls may be integrated within a variable bandwidth system so as to avoid unacceptable delays.

STATEMENT OF INVENTION

According to one aspect of the present invention, there is provided a mobile communication system in which the bandwidth available for an individual call between a mobile communications terminal and a base station is varied according to the demand for bandwidth during that call. Advantageously, the bandwidth may be increased when a large quantity of data is to be sent, but is reduced at other times and the additional capacity made available to other users.

According to another aspect of the present

invention there is provided a method of assigning time slots to individual calls in a TDMA mobile communication system, in which multiple slots within a frame which relate to a real-time call are spaced apart from each other in the frame. Advantageously, this slot allocation scheme reduces the delay incurred by the TDMA frame structure.

According to another aspect of the present invention, there is provided a method of time slot allocation in a TDMA mobile communications system, in which some of the slots are used to carry call traffic to and from mobile terminals, while other slots are used for setting up calls to other mobile terminals. In this way, signalling traffic may be combined with call traffic in the same frequency channel, reducing the need for separate signalling channels.

According to another aspect of the present invention, there is provided a combined TDMA and contention-based communication system, in which some time slots within a frame are allocated to specific mobile terminals, while other slots within the frame are designated as being available for contention-based access, so that additional terminals attempting to access the system may signal in the contention-based access slots. Advantageously, this arrangement allows the same frequency channel to be used for both

communications traffic and call set-up.

Brief Description of the Drawings

Embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a satellite communication system according to an embodiment of the present invention;

Figure 2 is a diagram of a protocol layer structure employed by the embodiment of Figure 1;

Figure 3 is a diagram of structure of a TDMA frame according to the air interface protocol of the embodiment of Figure 1;

Figure 4 is a diagram of the states of the mobile terminal in the embodiment of Figure 1, showing the possible transitions between them;

Figure 5 is a flow diagram of the operation of the mobile terminal beginning from the unlocated state of Figure 4;

Figure 6 is a flow diagram of the operation of the mobile terminal beginning from the idle state of Figure 4;

Figure 7 is a flow diagram of the operation of the mobile terminal beginning from the signalling state of Figure 4; and

Figure 8 is a flow diagram of the operation of

the mobile terminal beginning from the active state of Figure 4.

System Overview

Fig. 1 shows schematically a mobile terminal connected via a satellite 12 to a network management centre 18, which allocates bandwidth to the mobile terminal and connects the mobile terminal to a terrestrial network 22. In this embodiment, the mobile terminal 2 comprises a portable computer on which a number of different communications applications 4a, 4b, 4c, 4d may be run. For example, the applications may be a voice telephony application, an internet application, a facsimile application and an ATM application. Each of these applications use standard application programming interfaces (API) such as Winsock for internet access, TAPI for telephony applications and CAPI for ISDN applications. The interfaces to such applications are shown schematically by the reference I2 in Fig. 1. Driver software 6 running on the mobile terminal 2 converts API protocols to proprietary protocols designed for the satellite communication system. The mobile terminal 2 provides a physical interface I4 to an interface card 8, such as a PC (formerly PCMCIA) card. The interface card 8 includes a radio frequency modulator/demodulator connected to an antenna 10. The

radio frequency modulator/demodulator is able to receive on a first frequency channel and to transmit simultaneously on a second frequency channel.

The antenna 10 is located within the coverage region of a spot beam B generated by the satellite 12, which may for example be a geostationary satellite having multibeam receive/transmit antennas for receiving and transmitting signals in each of a plurality of spot beams B. Each spot beam B carries a plurality of frequency channels both in the forward and return directions. The satellite also receives and transmits in a global beam G which has a coverage area extending substantially or completely over the coverage areas of the spot beams B. The global beam B carries at least one forward and one return frequency channel.

The RF signals transmitted between the antenna 10 and satellite 12 comply with an air interface protocol I3, which will be more fully described hereafter. The satellite 12 acts as a repeater and converts channels from multiple spot beams B into channels in a feeder beam F and vice versa. The feeder beam F provides a link between the satellite 12 and an earth station 16 via an earth station antenna 14. The air interface protocol over the feeder beam F is referenced as I3F in Fig. 1.

The network management centre 18 is connected to the earth station 16 and includes a number of different service adaptors 20a, 20b, 20c, 20d providing an interface to terrestrial networks 22, such as PSTN, ATM networks or ISDN. For example, the service adaptors 20 may comprise a telephony adaptor 20a including a codec for converting voice signals on a PSTN to data at the network management centre 18 and *vice versa*. A facsimile service adaptor 20b may implement facsimile protocols, such as defined in ITU Recommendations T.30 and T.4 and include a modem for communication over a PSTN. An internet service adaptor 20c implements TCP/IP and an ATM service adaptor 20d implements ATM protocols. These standard protocols and interfaces are designated collectively by I1 in Fig. 1.

The mobile terminal 2 allows multiple different types of communication to be set up over the satellite communication system, such as telephony, internet, fax and ATM. These applications may be run concurrently. The bandwidth allocated to each application may be varied independently in the forward and return directions during a call, as will be described below.

Air Interface Protocols

The implementation of the air interface protocols I3 and I3F, as performed by the driver software 6 of

mobile terminal 2 and by the network management centre 18, will now be described with reference to Figs. 2 and 3. The protocol structure is described in terms of "layers" which interwork with each other as shown in Figure 2.

The top layer comprises a slot management layer 28 which receives data D from and sends data D to the applications 4 or the service adaptors 20. The data is formatted in slots S, each comprising a cell, as shown in Figure 3. Each cell C comprises a header H and data D both of fixed length. The slot management layer 28 formats data into and out of slots containing such cells, and exchanges the slots with a TDMA layer 26 which controls the timing of transmission and reception of the slots S within TDMA frames FR, which are sent to or received from a physical layer 24.

The physical layer 24 corresponds to the interface I4, the interface card 8 and the antenna 10, providing a physical interface between the driver software 6 and the air interface I3, or corresponds to the earth station antenna 14 and earth station 16, which likewise provide a physical interface between the network management centre 18 and the satellite 12. In both cases, the physical layer 24 converts the frames FR to radio frequency signals RF and vice versa.

The slots S contain, in addition to the traffic data D, signalling information which is used to set up calls and to vary the assignment of bandwidth during a call. The creation and reception of these signals is performed by a session management protocol layer 30, which interworks with the slot management layer 28 and the TDMA layer 26 to receive or transmit signalling information within the cells C, in the header H and/or as data D.

As shown in Figure 3, each TDMA frame is transmitted or received in a format comprising 18 slots $S_1 \ldots . S_{18}$, each comprising a cell C, with a guard band G separating each slot. Each slot S also contains synchronisation and control information which is used to acquire the timing of the slots, and will not be discussed further.

Each slot S may be assigned to any mobile terminal 2 with which a call has been set up, under the control of the network management centre 18.

Alternatively, more than one cell may be transmitted in each slot, with each cell being assignable to a different call to or from the same mobile terminal or even to a different mobile terminal.

Call Management

The different states through which the mobile

terminal 2 passes during operation are shown in Figure 4. In order to communicate with the mobile terminal 2, the network management centre 18 determines in which spot beam B the mobile terminal 2 is located. If the mobile terminal 2 is being used for the first time, or has moved into a different spot beam B since it was last used, then the mobile terminal 2 is in an "unlocated" state. When the mobile terminal 2 has acquired a spot beam channel but is not handling any calls, it is in an "idle" state. When a first call is being set up with the mobile terminal 2, it enters a "signalling" state, unless the call set up fails in which case it returns to the "idle" state. When the first call has been set up, the mobile terminal 2 enters an "active" state and remains in the active state until all calls are terminated, when the mobile terminal 2 enters the "idle" state once again. If contact is lost with the spot beam channel, the mobile terminal 2 returns to the unlocated state. Each of these states will now be described in detail.

<u>Unlocated State</u>

Transitions from the unlocated state will now be described with reference to Figure 5.

When the mobile terminal 2 is activated i.e. switched on or otherwise enabled to communicate, the driver software 6 first tunes the interface card 8 to

the frequency of the spot beam B last used for communication (step 34), if there has been any previous communication. If the interface card 8 is able to receive in this spot beam B, the driver software 6 detects whether any of the applications 4 have requested that an outgoing call should be set up from the mobile terminal 2 (step 36). If so, the mobile terminal 2 enters the signalling state; otherwise it enters the idle state.

If the interface card 8 is unable to receive signals at the frequency of the previously used spot beam B, then the interface card 8 is tuned to the forward and return frequencies of the global beam G received by the satellite 12 (step 38). The mobile terminal 2 then transmits a "log-on" message (step 40) in the global beam return channel. The log-on message includes identification information identifying both the mobile terminal 2 and its current user, together with location information which is sufficient for the network management centre 18 to determine in which spot beam B the mobile terminal 2 is located. This information may be entered by the user of the mobile terminal (i.e. by indicating in what country the mobile terminal 2 is located), or may be derived by positioning equipment in the mobile terminal 2, such as a GPS (Global Positioning System) receiver.

Preferably, the positioning information is sufficient to identify in which spot beam B the mobile terminal 2 is located, but does not have sufficient accuracy to allow eavesdroppers to locate the mobile terminal 2 precisely and thereby pose a security risk. If one of the applications 4 has requested that a call be set up, the log-on message may also indicate that the mobile terminal 2 intends to establish a call.

The mobile terminal 2 then awaits a response from the network management centre 18 in the forward channel of the global beam G (step 42). The response from the network management centre 18 includes identification information so that the response may be correlated with the log-on message, spot beam channel identification information which identifies the frequency channel to be used by the mobile terminal 2 for communication in the spot beam B in which it is located, and timing information derived from the timing of the log-on message as received by the earth station 16, to assist the mobile terminal 2 in synchronising with the timing of the frames FR. If the mobile terminal 2 indicated in the log-on message that a call is to be set up, the response includes a label which is used in a slot negotiation phase, as will be described later.

The interface card 8 is then tuned to the spot

beam channel indicated by the response (step 44). If no calls are currently required either from or to the mobile terminal, the mobile terminal 2 enters the idle state while continuing to monitor the spot beam forward channel, otherwise it enters the signalling state (step 46).

Idle State

In the idle state, as shown in Figure 6, the mobile terminal 2 continuously detects whether it is able to receive frames correctly in the designated spot beam channel (step 48). If it is no longer able to do so, the driver software 6 enters the unlocated state. Otherwise, the mobile terminal 2 detects whether any of the applications 4 require an outgoing call to be set up (step 50). If so, the mobile terminal 2 transmits a request message (step 52) in a slot S reserved for such signalling in the return spot beam channel. The allocation of such slots S is periodically indicated by the network management centre 18 in the forward direction spot beam channel. Access to such slots is determined by a slotted aloha access scheme, with the possibility of collision if two mobile terminals 2 attempt to transmit in the same slot, in which case the network management centre 18 will not receive either request message. The request message contains identification information

identifying the mobile terminal 2.

In response to the request message, the network management centre 18 sends a "welcome" message, including a label which is used as a temporary identity code for the mobile terminal 2. If the mobile terminal 2 detects the welcome message (step 54) it enters the signalling state; otherwise, the request is repeated (step 52) after a predetermined period. The period is increased after each unsuccessful request (step 52) and includes a randomised component, to avoid repeated conflict for the same return channel slot with the same other mobile terminals sending request messages. After a predetermined number of unsuccessful requests, the terminal 2 returns to the idle state.

If a call originating from the terrestrial network 22 is to be connected to the mobile terminal 2, the network management centre 18 sends identifying information over the forward spot beam channel to the mobile terminal 2, to indicate that an incoming call is to be set up. If the mobile terminal 2 detects such an incoming call (step 56) it enters the signalling state; otherwise if there are no incoming or outgoing calls, the mobile terminal 2 stays in the idle state.

Signalling State

In the signalling state, as shown in Figure 7, a setup protocol exchange takes place (step 48), in which user authentication information is sent by the mobile terminal 2 to the network management centre 18 and the addresses of the call and calling parties are exchanged. A committed bit rate (CBR) and maximum bit rate (MBR) are established for each direction of the call. The committed bit rate is a bit rate which is guaranteed throughout the call. The maximum bit rate is the maximum rate that can be assigned to the new call at any stage during the call. These variables are used by the network management centre 18 during the call to determine the number of slots allocated to the mobile terminal 2. The MBR and CBR in each direction may be determined according to the type of the call and/or according to a request by the mobile terminal 2 during call set-up. For example, if the call is an internet connection to be used for web access by the mobile terminal 2, a low CBR and MBR are set in the return direction while a low CBR and a high MBR are set in the forward direction, the level of the MBR being set according to a request from the mobile terminal 2.

If setup fails for any reason (step 50), for example because the requested committed bit rate is

not available in the spot beam B, or the network management centre 18 is unable to connect the call through the terrestrial network, the mobile terminal 2 returns to the idle state.

After the setup exchange, the mobile terminal 2 may retune (step 52) to a different channel within the spot beam B if the channel assigned during setup is not the same as the channel being used for the call.

If setup is successful, the mobile terminal 2 enters the active state.

<u>Active State</u>

Once the mobile terminal 2 is in the active state, additional signalling may take place between the mobile terminal 2 and the network management centre 18 so as to terminate a call, to exchange charging information or system information, to request more or less bandwidth for a call or to establish another call. This information is preferably sent in one or more of the slots already assigned to the mobile terminal 2. Alternatively, in the forward direction the network management centre 18 may send signalling information in a cell C of a slot S which is not committed to any mobile terminal 2, and indicate in the header information of this cell that the cell contains signalling information addressed to the mobile terminal 2.

An example of a protocol exchange which may take place in the active state of the mobile terminal 2 is shown in Figure 8. The mobile terminal 2 detects whether an incoming or outgoing call has been terminated (step 58). If so, it detects (step 60) whether there are now no incoming or outgoing calls. If so, the mobile terminal 2 enters the idle state, while remaining tuned to its current forward and return spot beam channels; otherwise, it continues in the active state.

The mobile terminal 2 also detects whether any additional calls are to be set up (step 62), either signalled by one of the applications 4 in the case of an outgoing call or indicated in a forward direction cell C from the network management centre 18 in the case of an incoming call. The mobile terminal 2 determines, by means of a signalling exchange with the network management centre 18, whether the committed bit rate required for the new call is available (step 64). If not, the driver software 6 determines whether a lower CBR than the requested CBR is suitable and available for the new call (step 66). If so, the new call is set up (step 68) by assigning additional slots to the new call within the same frequency channels, in addition to the slots which may already be assigned to other calls connected to the mobile terminal 2.

If the lower committed bit rate is not available or acceptable, the call is terminated (step 70) and the mobile terminal 2 continues in the active state, unless there are no other calls in progress in which case the idle state is entered.

If the requested capacity is not available in the frequency channel to which the mobile terminal is currently tuned, but is available in another channel, the network management centre 18 may signal to the mobile terminal 2 that the option is available of retuning to another channel and reassigning slots in that channel. If the mobile terminal 2 accepts, it retunes to the new channel and receives a new slot assignment in that channel from the network management centre 18.

While the mobile terminal 2 is in its active state, one of the applications 4 may enter a state in which the driver software 6 detects that additional bandwidth is required (step 72). For example, the application may begin to output a large graphics or audio file. In that case, the mobile terminal 2 signals in one of the assigned slots of the return channel that additional slots are required (step 74) in the return direction. If the current bit rate assigned to that call is less than the maximum bit rate, and additional capacity is available in the

frequency channel to which the mobile terminal 2 is tuned, the network management centre 18 assigns additional slots to the call in the return direction and signals to the mobile terminal which additional slots may be used in the return direction.

Slot Assignment

The system by which slots are assigned to the mobile terminal 2 in both the forward and return direction will now be described in detail. Once the mobile terminal 2 has left the unlocated state, it is tuned to receive one spot beam frequency channel in the forward direction and to transmit in another spot beam frequency channel in the return direction. Each mobile terminal 2 continuously receives in the forward frequency channel, but transmits only in the slots in the return channel which have been assigned to that mobile terminal, and optionally in the slots which have been designated for sending request messages, as described above. The forward and return slots can contain both signalling and call traffic.

As shown in Figure 3, each cell comprises a header H and data D. The header comprises four bytes, formatted as shown below in Table 1.

Table 1

8	7	6	5	4	3	2	1	Bit Octet
Label						PTI (bits 0,1)		1
PTI (bit 2)	CLP	Return Assignment or Bandwidth Demand						2
VCI								3
HEC								4

A description of each of the fields shown in Table 1 is given below.

Label

The label field contains the label of the mobile terminal which is intended to receive the cell or which transmitted the cell. As described above, the label is a temporary identity code which is assigned to each mobile terminal 2 when it is in the active or signalling state. When the mobile terminal 2 returns to the idle state, its label may be reassigned by the network management centre 18 to another mobile terminal 2. In this way, the number of bits needed to address a mobile terminal is reduced. Since each frame FR of a frequency channel contains 18 slots, only 18 different labels are need to identify each of the different mobile terminals tuned to that frequency channel. Six bits are assigned to the label field, allowing additional labels to be used for other

purposes. For example, a further label may indicate that the cell contains a broadcast message addressed to all the mobile terminals receiving the frequency channel, or for signalling purposes.

After a mobile terminal returns to the idle state, its label is not made available for reassignment for a predetermined period, to avoid the possibility of the same label being used for two different mobile terminals on the same frequency channel due to loss of call state synchronization between the network management centre 18 and the mobile terminal entering the idle state.

Return Assignment

In the forward direction, this field contains the label of the mobile terminal which is allowed to transmit in the corresponding slot of the return channel, for example the slot having the same order in the frame of the return channel.

Bandwidth Demand

This field is used in the return direction to indicate the bandwidth required by the transmitting mobile terminal 2 for all its calls in the return direction. One bit of the bandwidth demand field indicates that additional slots are required in the return direction for signalling purposes, thus allowing signalling to take place without reducing the

bandwidth available to currently active calls.

Virtual Channel Identifier (VCI)

This field identifies the individual call with which the cell C is associated, thus allowing a single mobile terminal to support multiple concurrent calls. The driver software 6 identifies the VCI of each cell C addressed to the mobile terminal and directs the contents of the cell to the corresponding application 4. Likewise, data from an active application is assigned a VCI when formatted into a cell by the driver software 6.

Payload Type Identifier (PTI)

This field is present for ATM compatibility, and is passed transparently by the satellite communication system, to allow interworking with terrestrial ATM services through the terrestrial network 22.

Cell Loss Priority (CLP)

This field is also present for ATM compatibility, and is passed transparently by the satellite system.

Header Error Control (HEC)

This field contains a check value calculated from the values from the other three bytes of the header, to allow corrupted headers to be detected.

Bandwidth Allocation

The network management centre 18 receives the bandwidth demand fields from each of the mobile

terminals 2 transmitting in a single return frequency channel, and allocates return channel slots according to these bandwidth demands, and the committed and maximum rate of each call. The allocation of slots in the return channel is indicated by the return assignment field.

The network management centre 18 also determines which slots are addressed to each of the mobile terminals in the forward direction, according to the required capacity in a forward direction for each of the calls. Thus, the capacity allocated in the forward direction may be selected independently from the capacity allocated in the return direction, allowing asymmetric calls to be assigned only so much capacity as is needed in each direction.

The network management centre 18 buffers data received from the network 22 for transmission to the mobile terminal 2, and determines the number of slots assigned to each call in the forward direction, and therefore the current forward bit rate, so that the committed bit rate is provided but the maximum bit rate is not exceeded. The current forward bit rate may be determined according to the quantity of data buffered for that call at the network management centre, so that a burst of data from the network 22 will result in an increased forward bit rate.

Optionally, if capacity on a forward channel is still available even after the maximum bit rate has been assigned to all calls, the maximum bit rate may be exceeded by assigning further slots to calls for which large amounts of data are buffered.

By appropriate selection of the committed and maximum bit rate for each call, various different types of call may be implemented. For example, a voice call may have a maximum bit rate equal to its committed bit rate, which is the bit rate required for the voice signal. Non-real-time low bit-rate applications, such as E-mail, may be assigned a low committed bit rate, but a high maximum bit rate so as to clear buffered e-mail at the network management centre 18 when there is any unused channel capacity.

Billing Strategy

The network management centre 18 may compile billing information according to the committed and maximum bit rates assigned to each call. For example, the billing rate may be proportional to the committed bit rate, with a comparatively small surcharge proportional to the maximum bit rate. In this way, the total capacity of a frequency channel is shared between different mobile users according to their bandwidth requirements, with lower priority non real-time users being charged less for access to the

channel.

Real-time Calls

When determining the slot allocation for individual calls, the network management centre 18 takes into account whether the call is a real-time call (such as a voice call). For such calls, the delay in transmission to and from the mobile terminal 2 should be kept to a minimum. Therefore, where a real-time call occupies multiple slots in a frame, those slots are spaced apart and distributed as evenly as possible throughout the frame so as to reduce the maximum delay encountered by any of the data in the real-time call. For example, Table 2 below shows the slot allocation where four different voice calls, V1 to V4, are established to four different mobile terminals 2, with each call V occupying four slots S within the frame FR, while Table 3 shows, by way of comparison, an arrangement in which the slots assigned to each call V are grouped together.

Table 2

V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4		

Table 3

V_1	V_1	V_1	V_1	V_2	V_2	V_2	V_2	V_3	V_3	V_3	V_3	V_4	V_4	V_4	V_4		

In the case shown in Table 3, the data for each

call may be buffered for up to one complete frame period. In contrast, the method in accordance with this embodiment, as shown in Table 2, requires data to be buffered for only a small fraction of the frame period, thereby reducing both delay and the size of the buffer required. Real-time calls are therefore given priority when allocating slots, so as to achieve regular spacing of the relevant slots through the frame. Non real-time variable bandwidth calls are then allocated to the remaining slots available so as to assign the committed bit rate to each of these calls. Surplus capacity is then allocated according to demand by the mobile terminals, subject to the maximum bit rate for each call.

While the above embodiment is described with reference to a satellite communications system, aspects of the present invention may also be applied to terrestrial cellular communications systems. The mobile terminal may be portable, may be mounted on a vehicle or form part of a temporary or permanent installation, such as a temporary office building or a wireless telephone booth.

Elements of the embodiment are described in terms of functional blocks. These blocks do not necessarily correspond to discrete units, but functions of more than one functional block may be performed by one discrete

unit, or the function of one functional block may b performed by more than one discrete unit.

Although the preferred channel format is TDMA, aspects of the present invention may also be applied to CDMA communications systems.

CLAIMS

1. A method of communication to or from a mobile terminal at a base station connected to a communications network, comprising setting up a call between a network terminal connected to the network and the mobile terminal, determining a current bandwidth allocation for the call over a wireless link between the base station and the mobile terminal, and varying the current bandwidth allocation during the call in accordance with a bandwidth demand relating to the call.

2. A method as claimed in claim 1, wherein the current bandwidth allocation includes a return bandwidth allocation, further comprising receiving a demand signal at the base station from the mobile terminal, the return bandwidth allocation being varied in accordance with said demand signal, the method further comprising transmitting from the base station to the mobile terminal allocation data indicating the return bandwidth allocation, such that the mobile terminal uses the return bandwidth allocation for transmission to the base station.

3. A method as claimed in claim 1 or 2, wherein the current bandwidth allocation includes a forward

bandwidth allocation, the forward bandwidth allocatio being varied during the call in accordance with a forward channel demand relating to the call, the method further comprising transmitting from the base station to the mobile terminal using the forward bandwidth allocation.

4. A method as claimed in claim 3, wherein the forward channel demand is derived from the quantity of data received from the network terminal during the call.

5. A method as claimed in claim 3 or 4, each when dependent on claim 2, wherein the forward bandwidth allocation is determined independently of the return bandwidth allocation.

6. A method as claimed in any preceding claim, wherein the step of setting up the call includes the step of determining a maximum bandwidth allocation for that call, and the current bandwidth allocation is varied without exceeding said maximum bandwidth allocation.

7. A method as claimed in any preceding claim, wherein the step of establishing said call includes determining a minimum bandwidth allocation for that call, and the current bandwidth allocation is varied without falling

below said minimum bandwidth allocation.

8. Apparatus for communication between a mobile terminal and a network terminal connected to a network comprising:

means for setting up a call between the mobile terminal and the network terminal,

means for determining a current bandwidth allocation for the call over a wireless link between the base station and the mobile terminal, and

means for varying the current bandwidth allocation during the call in accordance with a bandwidth demand relating to the call.

9. A method of assignment for assigning time slots within a frame of a TDMA frequency channel to a plurality of calls between a base station and one or more mobile terminals, comprising:

determining which of said calls are real-time calls requiring a plurality of time slots per frame; and

allocating said time slots in said frame to said calls such that the plurality of time slots allocated to each of said real-time calls are mutually spaced apart in said frame.

10. A method as claimed in claim 9, wherein said TDMA

frequency channel is a forward channel for communicatio with said one or more mobile terminals, the method further comprising transmitting call signals in said time slots in accordance with the allocation of said slots.

11. A method as claimed in claim 9, wherein said TDMA frequency channel is a return channel for communication from said one or more mobile terminals to said base station, the method further comprising:

transmitting to said one or more mobile terminals information relating to the allocation of said slots in the return channel, such that call signals are transmitted by said one or more mobile terminals in the allocated slots of the return channel.

12. Apparatus for assigning time slots within a frame of a TDMA frequency channel to a plurality of calls between a base station and one or more mobile terminals, comprising:

means for determining which of said calls are real-time calls requiring a plurality of time slots per frame; and

means for allocating said time slots in said frame to said calls such that the plurality of time slots allocated to each of said real-time calls are mutually

spaced apart in said frame.

13. A method of communication from a base station to one or more mobile terminals over a TDMA frequency channel, comprising:

allocating to said one or more mobile terminals respectively one or more time slots of said TDMA channel such that call traffic addressed to each of said mobile terminals is transmitted in the respective one or more slots; and

reserving remaining ones of said slots not allocated for call traffic during said allocating step for signalling traffic such that call set-up signals are transmitted in said reserved slots to a further one or more mobile terminals.

14. Apparatus for communication from a base station to one or more mobile terminals over a TDMA frequency channel, comprising:

means for allocating to said one or more mobile terminals respectively one or more time slots of said TDMA channel such that call traffic addressed to each of said mobile terminals is transmitted in the respective one or more slots;

means for reserving for signalling traffic remaining ones of said slots not allocated for call

traffic and

means for transmitting call traffic signals in the respective allocated slots and call set-up signals in said reserved slots.

15. A method of communication between a base station and first and second groups of mobile terminals, comprising:

transmitting to said first and second groups of mobile terminals allocation information indicating the allocation of a first set of divisions of a return frequency channel to calls from specified ones of said first group of mobile terminals and further indicating the allocation of a second set of divisions of said return frequency channel as signalling divisions available to any one of said second group of mobile terminals, whereby the base station receives in said first set of divisions call signals from the respective specified ones of said first group of mobile terminals and receives in each of said second set of divisions signals from one of said second group of mobile terminals.

16. A method as claimed in claim 15, wherein said return frequency channel is a TDMA frequency channel and said divisions comprise time slots in said TDMA

frequency channel.

17. A method as claimed in claim 15, wherein said return frequency channel is a CDMA frequency channel and said divisions comprise code divisions of said CDMA frequency channel.

18. Apparatus for communication between a base station and first and second groups of mobile terminals, comprising:

means for transmitting to said first and second groups of mobile terminals allocation information indicating the allocation of a first set of divisions of a return frequency channel to calls from specified ones of said first group of mobile terminals and further indicating the allocation of a second set of divisions of said return frequency channel as signalling divisions available to any one of said second group of mobile terminals.

19. A method of communication from a mobile terminal to a base station, comprising:

i) receiving at the mobile terminal from the base station allocation information indicating the allocation of a first set of divisions of a return frequency channel to specified mobile terminals other than said

mobile terminal and the allocation of a second set of divisions of the return frequency channel as signalling divisions,

ii) transmitting in one of said second set of divisions of the return frequency channel a call set-up request signal;

iii) detecting whether a response to the call set-up request signal is received from the base station within a predetermined period, and, if no response is received, repeating steps i) to iii) until the response is received or a failure condition is detected.

20. A method as claimed in claim 19, wherein the return frequency channel is a TDMA frequency channel and the divisions comprise time slots of the TDMA channel.

21. A method as claimed in claim 19 or 20, wherein the predetermined period is increased for each repetition of steps i) to iii).

22. A method as claimed in any one of claims 19 to 21, wherein the predetermined period includes a predetermined random or pseudo-random period for each repetition of steps i) to iii).

23. A method of registering a communications terminal with a satellite communications system including a satellite generating a plurality of spot beams each carrying at least one spot beam transmission channel and a global beam substantially encompassing the plurality of spot beams and carrying at least one global beam reception channel and at least one global beam transmission channel, said method comprising:

receiving a call on one said spot beam transmission channel;

ceasing reception of said call;

subsequently determining whether said one spot beam transmission channel is receivable by said terminal; and,

if said one spot beam transmission channel is not receivable, transmitting a registration message in said global beam reception channel;

receiving a spot beam channel allocation signal in said global beam transmission channel; and

receiving a further said spot beam transmission channel selected according to said spot beam channel allocation signal.

24. Apparatus as herein described with reference to the accompanying drawings.

25. A method substantially as herein described wit' reference to the accompanying drawings.

Abstract

Communication Method and Apparatus

A satellite communications system provides a communications service to a mobile terminal 2 on which different communications applications 4a to 4d may be run. Calls are set up between any of the applications 4a to 4d via a satellite 12 to a network management centre 18 which provides different service adaptors 20a to 20d which adapt the calls to different types of service provided over terrestrial networks 22, such as telephony, facsimile, internet or ATM services.

The bandwidth allocated to each call over the satellite link may be varied during the call according to demand either from the relevant application 4 or from the network management centre 18. Multiple calls may be connected concurrently to or from different applications running on the mobile terminal.

Efficient use is thereby made of the limited bandwidth available over the satellite 12, according to the instantaneous bandwidth requirements of different applications 4.

[Figure 1]

THIS PAGE BLANK (USPTO)

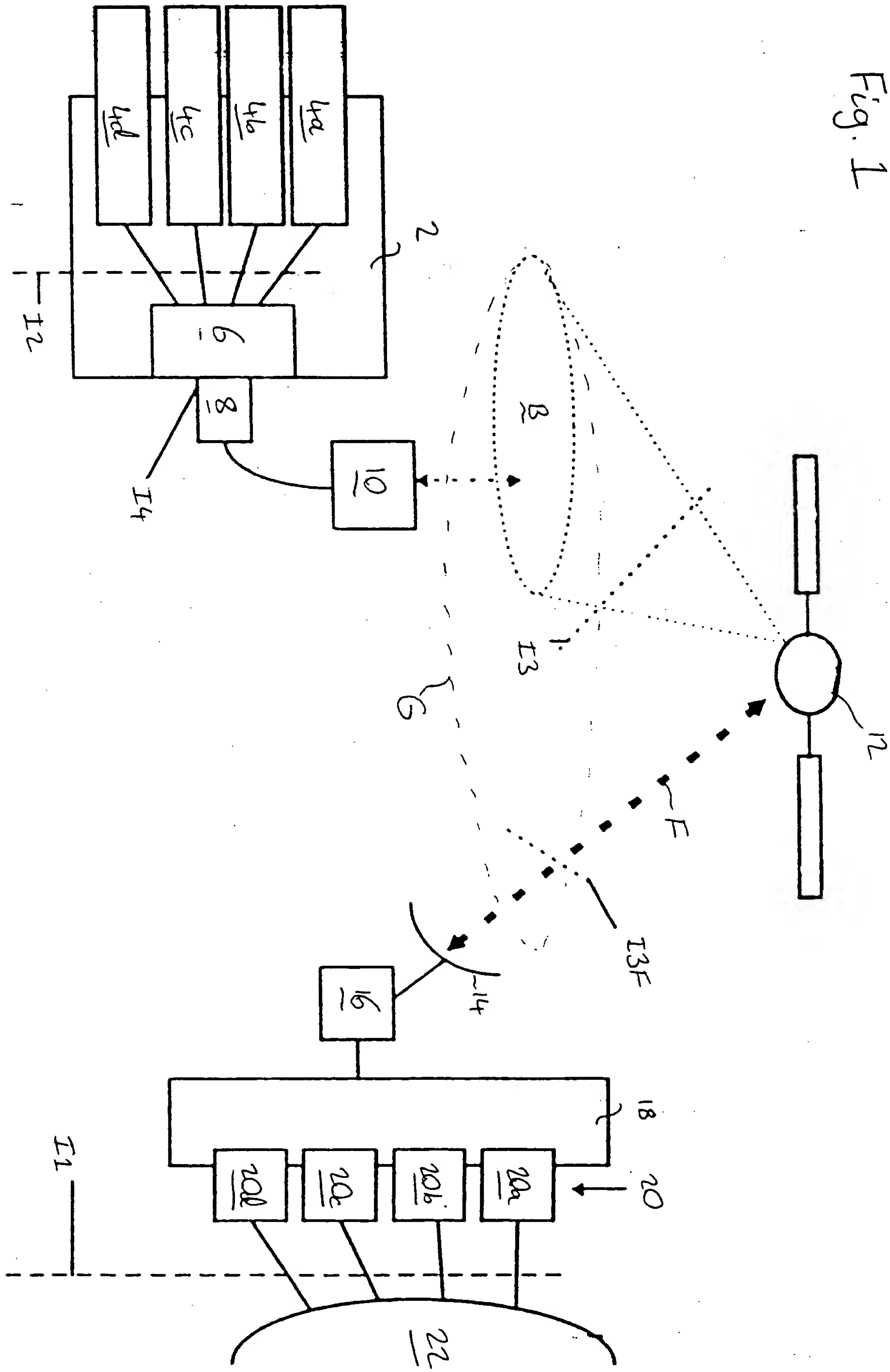

4a
4b
4c
4d
2
6
I2
8
I4
10
B
G
I3
12
F
I3F
14
16
18
20
20a
20b
20c
20d
I1
22

Fig. 1

THIS PAGE BLANK (USPTO)

Fig. 2

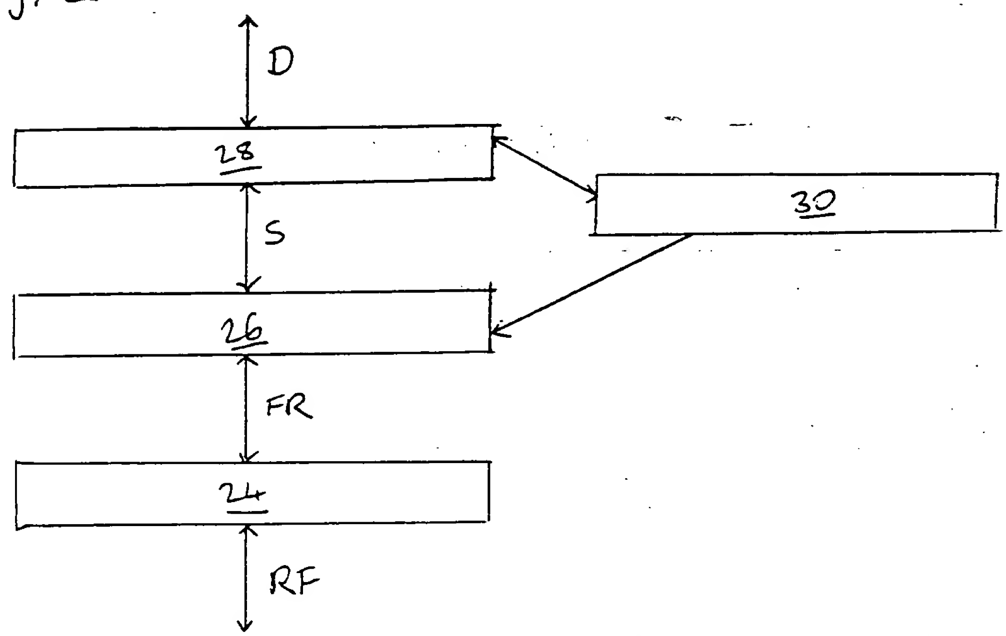


Fig 3

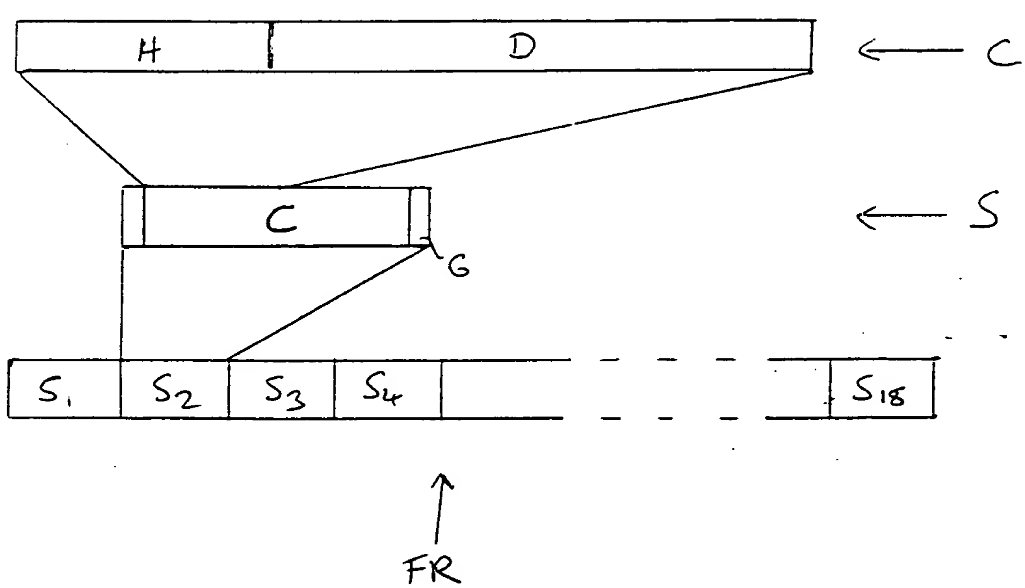


Fig. 4

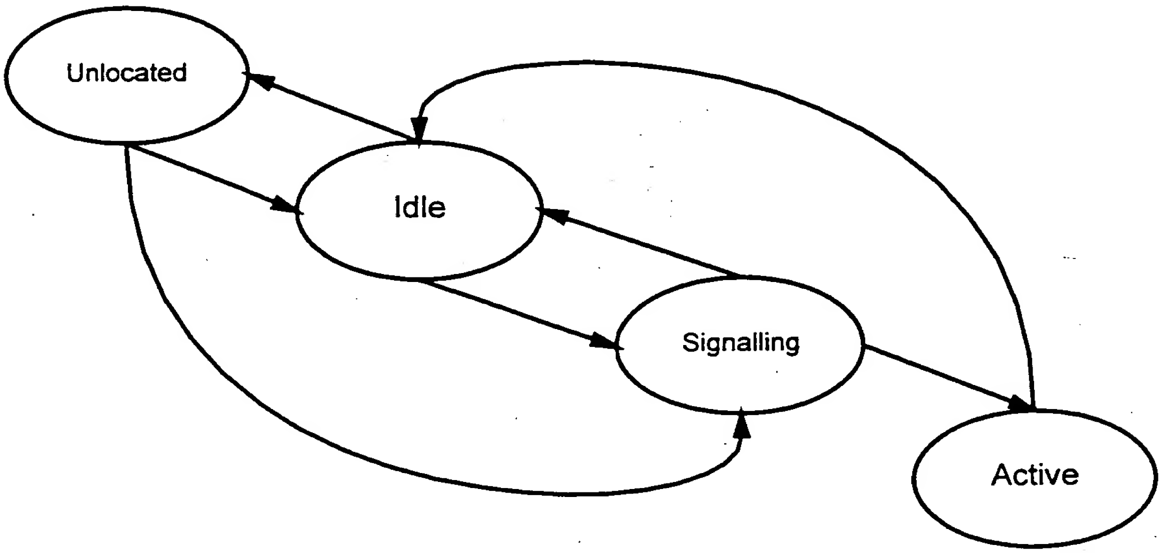
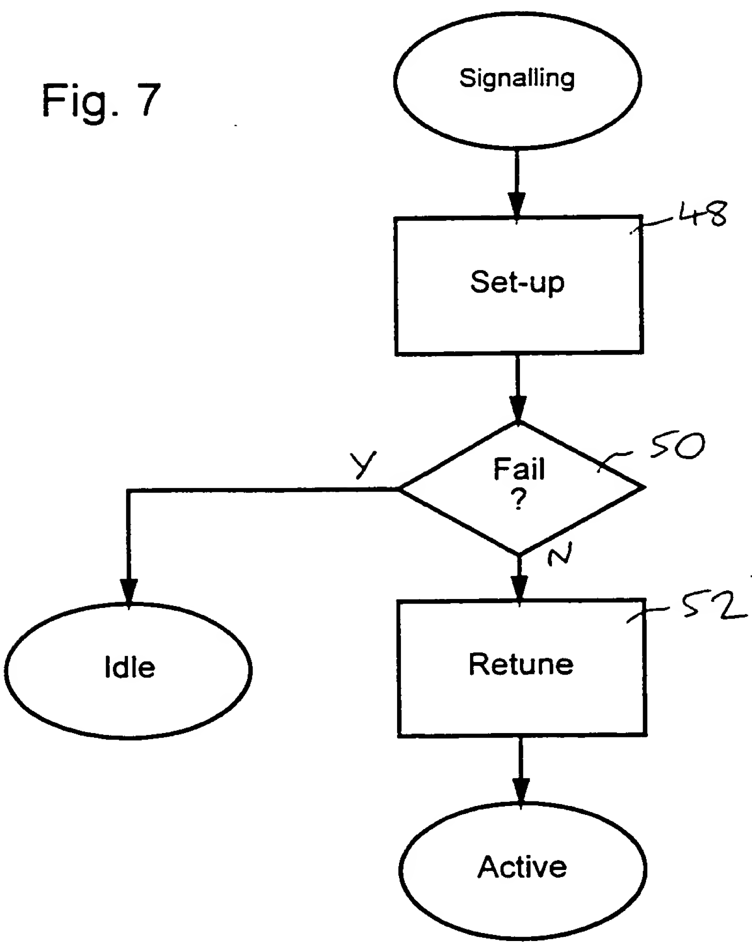
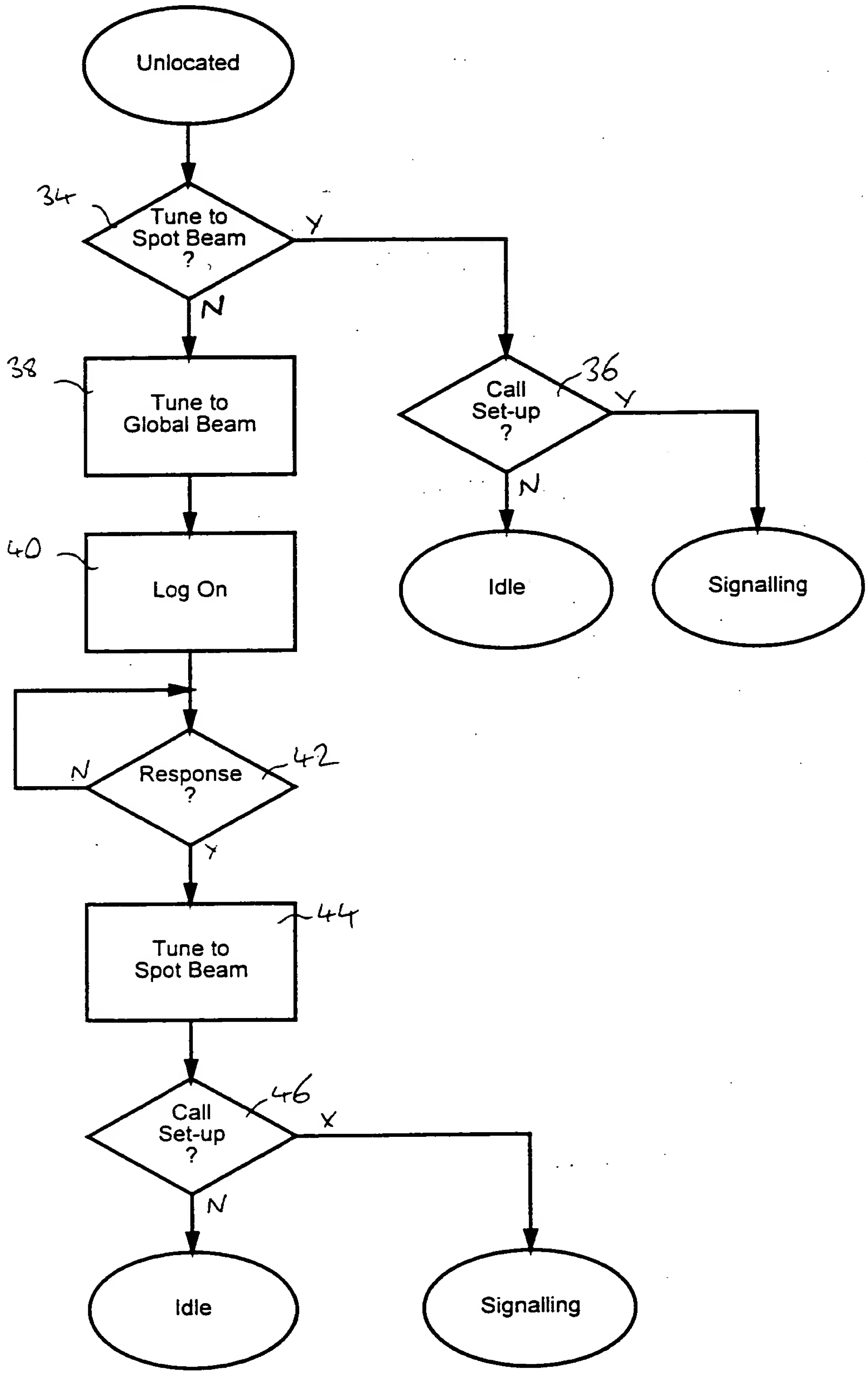

Unlocated
Idle
Signalling
Active

Fig. 7


Signalling
48
Set-up
50
Fail ?
Y
N
52
Idle
Retune
Active

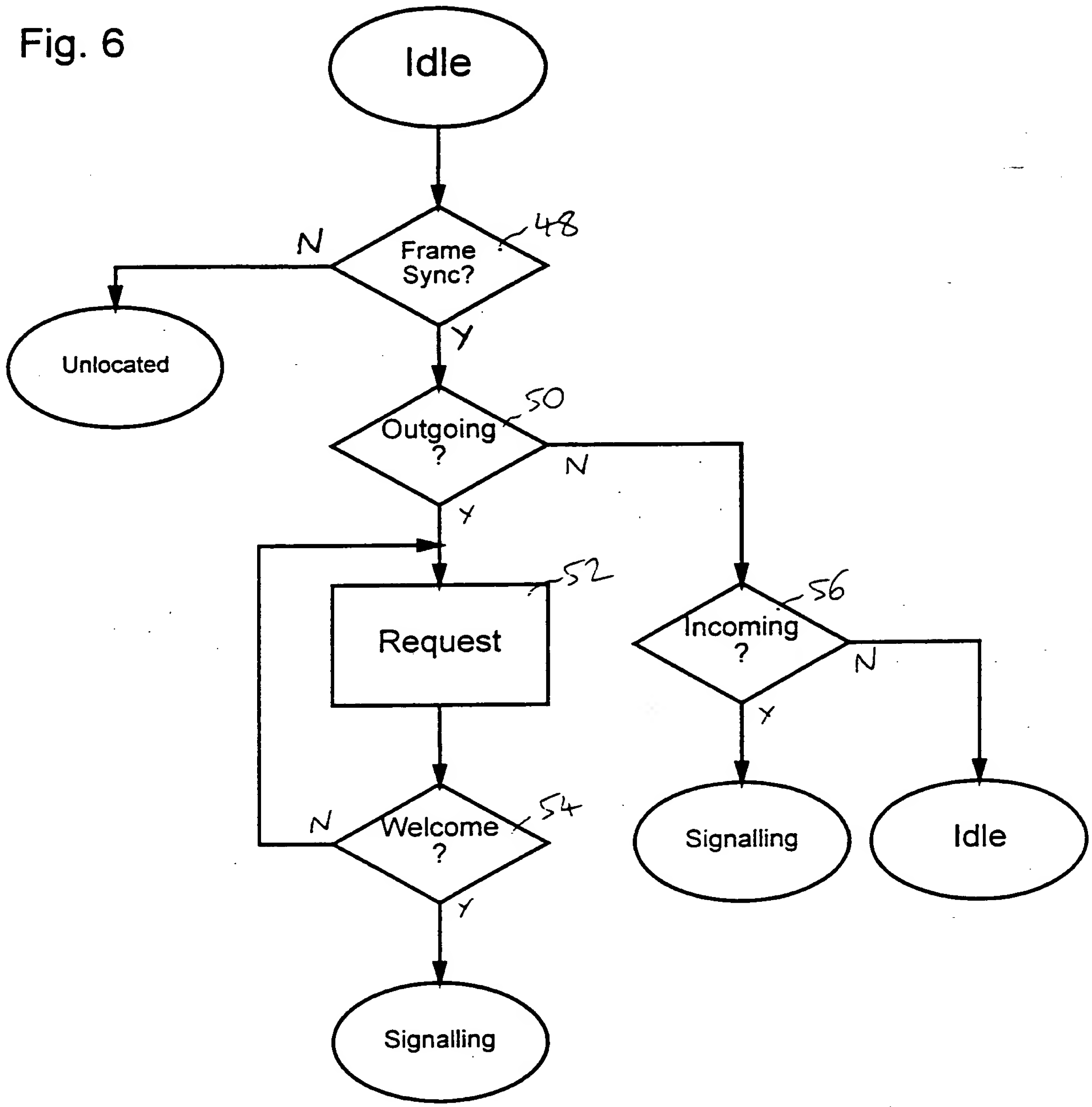
THIS PAGE BLANK (USPTO)

Fig. 5


Unlocated
34
Tune to Spot Beam ?
Y
N
38
Tune to Global Beam
40
Log On
Response ?
42
N
Y
Tune to Spot Beam
44
Call Set-up ?
46
X
N
Idle
Signalling
Call Set-up ?
36
Y
N
Idle
Signalling

THIS PAGE BLANK (USPTO)

Fig. 6


Idle
Frame Sync?
48
N
Unlocated
Y
Outgoing ?
50
N
Y
Request
52
Incoming ?
56
N
Y
Welcome ?
54
N
Y
Signalling
Idle
Signalling

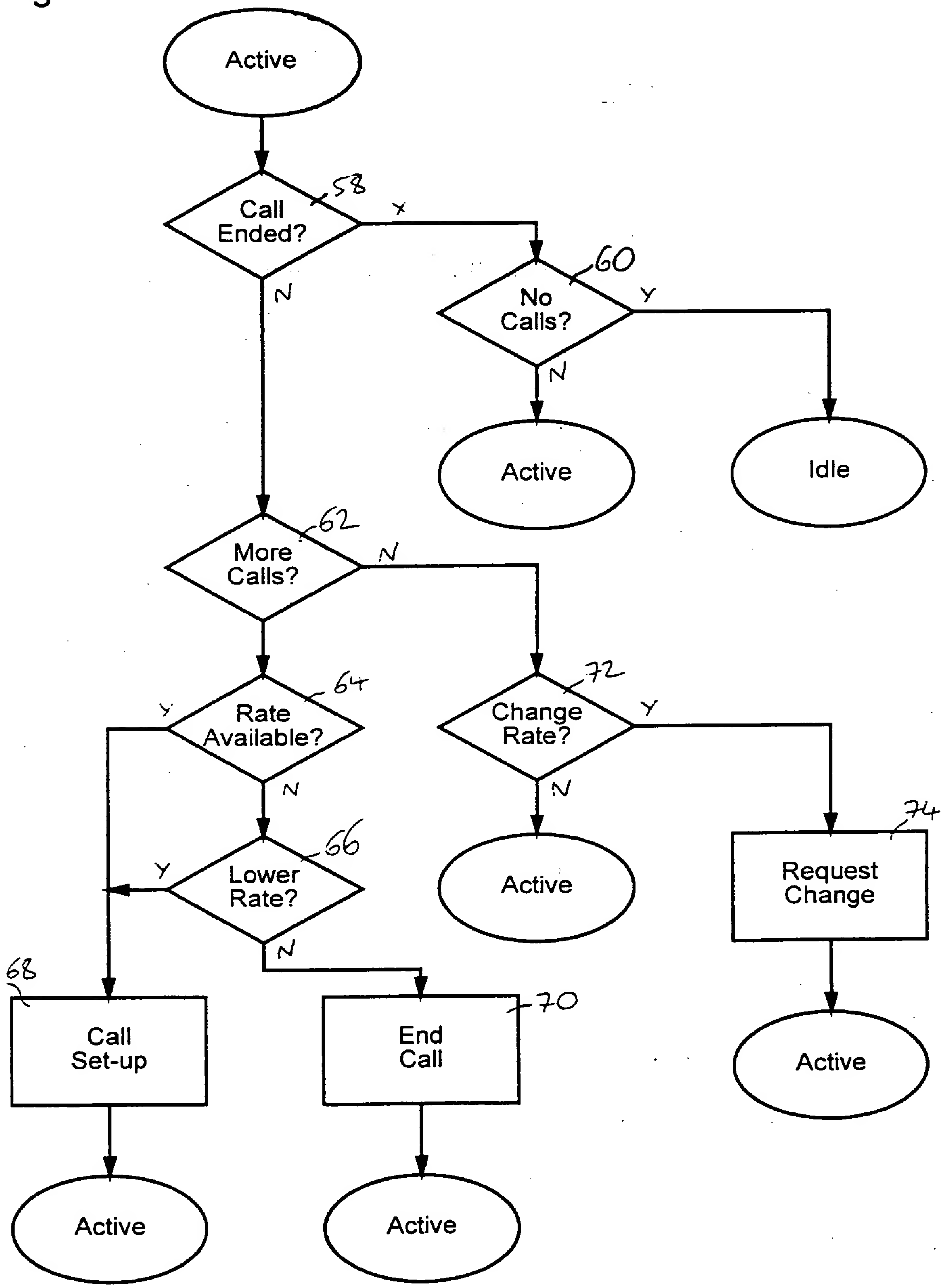

Active
Call Ended?
58
Y
N
60
No Calls?
Y
N
Active
Idle
62
More Calls?
N
64
Rate Available?
Y
N
72
Change Rate?
Y
N
66
Lower Rate?
Y
N
Active
74
Request Change
68
Call Set-up
70
End Call
Active
Active
Active

Fig. 8

PCT/GB 97/03344

R. G. C. JENKINS

8/1/98

THIS PAGE BLANK (USPTO)